



**Faculty of Mechanical and Manufacturing Engineering  
Technology**

**OPTIMIZATION PARAMETER OF BORON TOOL WEAR WITH  
SURFACE TEXTURE FOR AISI 1018 LOW CARBON STEEL IN WET  
TURNING PROCESS**

**Muhammad Rahdi bin Zulkafli**

**Bachelor of Manufacturing Engineering Technology (Process and Technology) with  
Honours**

**2018**

**OPTIMIZATION PARAMETER OF BORON TOOL WEAR WITH  
SURFACE TEXTURE FOR AISI 1018 LOW CARBON STEEL IN WET  
TURNING PROCESS**

**MUHAMMAD RAHDI BIN ZULKAFLI**

**This report is submitted in accordance with the requirement of the Universiti  
Teknikal Malaysia Melaka (UTeM) for the Bachelor of Manufacturing Engineering  
Technology (Process & Technology) with Honours**

**Faculty of Mechanical and Manufacturing Engineering Technology**

**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**2018**

## BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

**TAJUK: Optimization Parameter of Boron Tool Wear with Surface Texture for AISI 1018 Low Carbon Steel in Wet Turning Process**

**SESI PENGAJIAN: 2018/2019 Semester 1**

Saya **MUHAMMAD RAHDI BIN ZULKAFI**

mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **\*\*Sila tandakan (✓)**

SULIT

(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972)

TERHAD

(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)

TIDAK TERHAD

Disahkan oleh:

\_\_\_\_\_

\_\_\_\_\_

Cop Rasmi:

Alamat Tetap:

No.28, Lorong 1, Taman Dato Abdul  
Rashid Salleh, 25300 Kuantan,  
Pahang

Tarikh: \_\_\_\_\_

Tarikh: \_\_\_\_\_

**\*\* Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.**

## DECLARATION

I declare that this thesis entitled “Optimization Parameter of Boron Tool Wear with Surface Texture for AISI 1018 for Low Carbon Steel in Wet Turning Process” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

Name : .....

Date : .....

## APPROVAL

I hereby declare that I have read this report and in my opinion this report is sufficient in terms of scope and quality as a partial fulfilment for the Bachelor of Manufacturing Engineering Technology (Process and Technology) with Honours.

Signature : .....

Supervisor Name : .....

Date : .....

## **DEDICATION**

Especially dedicated to my beloved father, Mr Zulkafli bin Abdul Rahman and my beloved mother, Mrs Aminah binti Yusoh who are very concern, understanding, patient, and supporting. Special thanks to my supervisor Mr Mohd Hairizal bin Osman, for the constructive guidance, encouragement and patient in fulfilling my aspiration in completing this project.

## ABSTRACT

This project was carry out to determine the significant factor of parameter that influence the boron tool wear based on the surface texture design. The machining process was performed on the CNC turning machine by using the boron cutting tool insert with surface texture and the material that use is AISI 1018 low carbon steel. Besides that, the aim of this project is to optimize the parameter of boron cutting tool wear insert by utilizing the Taguchi method. The selection of parameter are surface texture, feed rate and spindle speed. The type of surface texture are perpendicular, eclipse and wavy. Then, value of feed rate that selecting are 0.04mm/ min, 0.06 mm/min and 0.08 mm/min. Besides that, the spindle speed are 400 rpm, 450 rpm, and 500 rpm. The experimental design by using L9 orthogonal array with 3 level and 3 factor. The experiment was conduct which three trial. The data was obtain by using SMZ 745T Optical Microscope. The Minitab software was use to analyses the data that get based on Taguchi design.

## ABSTRAK

*Projek ini dijalankan untuk menentukan faktor parameter penting yang mempengaruhi Kehausan mata alat Boron berdasarkan reka bentuk tekstur permukaan. Proses pemesinan dilakukan menggunakan mesin CNC larik dan pada mesin tersebut mata alat Boron dengan tekstur permukaan digunakan dan bahan yang digunakan untuk melarik adalah keluli karbon rendah AISI 1018. Di samping itu, tujuan projek ini adalah untuk optimumkan parameter kehausan mata alat Boron dengan menggunakan kaedah Taguchi. Pemilihan parameter adalah tekstur permukaan, kadar suapan dan kelajuan gelendong. Jenis tekstur permukaan adalah tegak lurus, gerhana dan ikal. Kemudian nilai kadar suapan yang dipilih ialah 0.04 mm/min, 0.06 mm/min dan 0.08 mm/min. Selain itu, kejauan gelendong adalah 400 rpm, 450 rpm dan 500 rpm. Reka bentuk eksperimen ini menggunakan array ortogonal L9 dengan 3 tahap dan 3 faktor. Tiga percubaan dijalankan bagi setiap eksperimen. Data diperolehi dengan menggunakan Mikroskop Optik SMZ 745T. Perisian Minitab digunakan untuk menganalisis data yang berdasarkan Reka bentuk Taguchi*



## ACKNOWLEDGMENTS

Alhamdulillah, Praise to God for His help and guidance that I am able to complete the task of this Bachelor Degree Project. I am thankful and grateful to my supervisor, Mr. Mohd Hairizal bin Osman for his advice and knowledge that he shared in the completion of the project. I am appreciate his help to me while I am doing the Bachelor Degree Project until I am finish it. Not to forget to Mr. Mohamad Ridzuan bin Mohamad Kamal, Mr. Muhammad Syafik bin Jumali and all the assistant engineers which are Mr. Azizul Ikhwan bin Mohd, Mr. Basri bin Bidin and Mr. Norhisyam bin Abdul Malik for give a lot of guidance and new knowledge to me during doing this Bachelor Project.

I also would like to thank all my friends who have been really helpful during the course of the conducting the Bachelor Degree Project. With a little help of ideas from them, I can complete this report.

I sincerely grateful to my parents for their love and their support for me throughout my life in all my activities that I have done. I also wanted to thank other people who have directly or indirectly help in the completion of my Bachelor Project. I sincerely appreciate all your help.

## TABLE OF CONTENT

<b>DECLARATION</b>	<b>iii</b>
<b>APPROVAL</b>	<b>iv</b>
<b>DEDICATION</b>	<b>v</b>
<b>ABSTRACT</b>	<b>vi</b>
<b>ABSTRAK</b>	<b>vii</b>
<b>ACKNOWLEDGMENTS</b>	<b>viii</b>
<b>TABLE OF CONTENT</b>	<b>ix</b>
<b>LIST OF TABLES</b>	<b>iii</b>
<b>LIST OF FIGURES</b>	<b>v</b>
<b>LIST OF APPENDICES</b>	<b>iii</b>
<b>LIST OF SYMBOLS</b>	<b>iv</b>
<b>INTRODUCTION</b>	<b>1</b>
1.0 Introduction	1
1.1 Project Background	1
1.2 Problem Statement	2
1.3 Objective	3
1.4 Work Scope	3
<b>LITERATURE REVIEW</b>	<b>4</b>
2.0 Introduction	4
2.1 Turning	4
2.1.1 Turning Machine	5
2.1.2 CNC Turning Machine	6
2.2 Wet Turning	7
2.2.1 Cutting Fluid	8
2.2.2 Types of Cutting Fluid	10
2.3 Laser Cutting	11
2.3.1 Laser Engraving	12
2.4 Surface Texture on Cutting Tool	13
2.5 Tool Wear	15
2.5.1 Crater Wear and Flank Wear	16

2.6 Carbon Steel	17
2.6.1 AISI 1018 Low Carbon Steel	19
2.7 Cutting Tool Material	19
2.7.1 Boron Steel	20
2.7.2 Hot Stamping	21
2.8 Parameter of Machining	22
2.8.1 Depth of Cut	24
2.8.2 Cutting Speed	24
2.8.3 Feed Rate	25
2.9 Minitab Software	25
2.10 Taguchi Method	26
2.11 Analysis of Variance (ANOVA)	28
<b>METHODOLOGY</b>	<b>30</b>
3.0 Introduction	30
3.1 Flow Chart	31
3.2 Gantt Chart	32
3.3 AISI 1018 Low Carbon Steel	34
3.4 Cutting Tool Insert Material	34
3.4.1 Surface Texture of Boron Steel Insert	35
3.5 Machining Parameter	36
3.5.1 CNC Laser Cutting Parameter	36
3.5.2 CNC Turning Parameter	37
3.6 Taguchi Method	37
3.6.1 Taguchi Method using Minitab	39
3.7 Machine Equipment	40
3.7.1 CNC Laser Cutting	41
3.7.2 CNC Turning Machine	42
3.7.3 Optical Microscope	43
3.7.4 Rockwell Hardness Testing Mitutoyo HR-400	44
3.7.5 Bandsaw Machine	45
3.7.6 Conventional Lathe Machine	46
3.7.7 Mitutoyo Horizontal Optical Comparator	47
3.8 Experimental Setup	48

3.8.1 Work Piece	48
3.8.2 Cutting Tool Boron Insert	49
3.8.2.1 Drawing of Cutting Insert	49
3.8.2.2 CNC Laser Cutting Process	50
3.8.3 CNC Turning Process Machining	51
3.9 Experimental Analysis	52
<b>RESULT</b>	<b>53</b>
4.0 Introduction	53
4.1 Finding and Results	53
4.2 Flank Wear Cutting Tool Insert Analysis	63
4.2.1 Mean and S/N Ratios Result of Flank Wear Cutting Tool Insert	64
4.2.2 The Graph Main Effects Plot for Means and S/N Ratios	65
4.2.3 Response Table for Mean and S/N Ratios	67
4.3 Analysis of Variance (ANOVA)	68
4.4 Taguchi Analysis Predicted	70
4.5 Confirmation Test	71
<b>DISCUSSION</b>	<b>72</b>
5.0 Introduction	72
5.1 Discussion of Material Hardness	72
5.2 Discussion of Flank Wear and Crater Wear	73
<b>CONCLUSION AND RECOMMENDATIONS FOR FUTURE RESEARCH</b>	<b>74</b>
6.0 Introduction	74
6.1 Summary of Research	74
6.2 Significant of Researches	75
6.3 Problem Faced During Research	75
6.4 Suggestion for Future Work	76
<b>REFERENCES</b>	<b>77</b>
<b>APPENDICES</b>	<b>81</b>

## LIST OF TABLES

Table 2. 1: Types of Cutting Fluid	10
Table 2. 2: Four Main Category of Carbon Steel	18
Table 2. 3: Chemical Composition of Boron Steel	21
Table 2. 4: Formula Related in Turning Machining	23
Table 2. 5: Parameter Machining with 3 Levels	27
Table 2. 6: Taguchi Orthogonal Array <i>L9</i>	27
Table 2. 7: Types of Signal to noise ratio	29
Table 3. 1: Gantt Chart of Scheduling PSM 1 and PSM 2	33
Table 3. 2: Types of Surface Texture on Cutting Tool	35
Table 3. 3: CNC Laser Engraving Cutting Parameter	36
Table 3. 4: Laser Cutting Parameter	36
Table 3. 5: CNC Turning Machining Parameter	37
Table 3. 6: Parameter for Three Factor and Level	38
Table 3. 7: Layout Design <i>L9</i> Orthogonal Array	38
Table 3. 8: Taguchi Analysis by using Minitab Software	39
Table 3. 9: Specification of AMADA FO MII 3015 NT	41
Table 3. 10: Main Spindle Designation of CTX310 ECOLINE	42
Table 3. 11: Specification of SMZ 745T Optical Microscope	43
Table 3. 12: Specification of the Rockwell Hardness Testing Mitutoyo HR-400	44
Table 3. 13: Specification of the Bandsaw Machine	45

Table 3. 14: Specification of the Conventional Lathe Machine	46
Table 3. 15: Specification of the Mitutoyo Horizontal Optical Comparator	47
Table 4. 1: The Taguchi L9 Orthogonal Array Layout	54
Table 4. 2: The Experimental Result of CNC Turning	55
Table 4. 3: Example Result of Tool Wear Analysis from SMZ745T Optical Microscope	57
Table 4. 4: Data Result for Right View Tool Wear	59
Table 4. 5: Data Result for Left View Tool Wear	60
Table 4. 6: Data Result for Mean Right and Mean Left View of Tool Wear	61
Table 4. 7: Result Value of Mean and S/N Ratios	65
Table 4. 8: Respond Table for Means	67
Table 4. 9: Respond Table for S/N Ratios Based on Smaller is better	67
Table 4. 10: Analysis of Variance for Means	68
Table 4. 11: Analysis of Variance for SN ratios	69
Table 4. 12: The Result of Confirmation Test	71
Table 5. 1: Material Hardness Value	72

## LIST OF FIGURES

Figure 2. 1: Fundamental of Turning Process to Produce the Cylindrical Part	5
Figure 2. 2: Main Part of CNC Turning Machine	6
Figure 2. 3: Wet Turning Process	7
Figure 2. 4: The Region of Heat Zone in Turning Process	8
Figure 2. 5: Lubricant Flow Due Between Tool and Chip Interference	13
Figure 2. 6: Surface Texture on the Tool Wear	14
Figure 2. 7: The Crater Wear and Flank Wear on The Cutting Tool	16
Figure 2. 8: Tool Geometry	17
Figure 2. 9: The Depth of Cut	24
Figure 3. 1: Flow Chart Process	31
Figure 3. 2: ASSI 1018 Low Carbon Steel Rod	34
Figure 3. 3: Boron Steel after Hot Stamping Process	35
Figure 3. 4: CNC Laser Cutting	41
Figure 3. 5: CTX310 ECOLINE CNC Turning Machine	42
Figure 3. 6: SMZ 745T Optical Microscope	43
Figure 3. 7: Rockwell Hardness Testing Mitutoyo HR-400	44
Figure 3. 8: Bandsaw Machine	45
Figure 3. 9: Conventional Lathe Machine	46
Figure 3. 10: Mitutoyo Horizontal Optical Comparator	47
Figure 3. 11: Cutting Process of Work Piece	48

Figure 3. 12: Work Piece after Facing and Turning Process.	49
Figure 3. 13: The Drawing of Perpendicular Insert Tool	49
Figure 3. 14: NC Code of Laser Cutting Machine	50
Figure 3. 15: Boron Steel Plate Attach to CNC Laser Cutting	50
Figure 3. 16: Cutting Tool Insert Attach to the Holder Tool	51
Figure 3. 17: Analyse Process of Flank Wear	52
Figure 3. 18: Image of Flank Wear	52
Figure 4. 1: Top View Tool Wear Insert Analysis	56
Figure 4. 2: Right View Tool Wear Insert Analysis	56
Figure 4. 3: Left View Tool Wear Insert Analysis	56
Figure 4. 4: S/N Ratios Smaller is Better Equation	63
Figure 4. 5: Graph of Main Effects Plot for Means	66
Figure 4. 6: Graph of Main Effects Plot for S/N Ratios	66
Figure 4. 7: The Predict Result for Mean and S/N Ratios for Cutting Tool Wear.	70
Figure 4. 8: The Calculation of Percentages Error	71



## **LIST OF APPENDICES**

Appendices A – Turnitin Checking

Appendices B – Drawing Cutting Design

Appendices C – Left Flank Wear Data

Appendices D – Right Flank Wear Data

## LIST OF SYMBOLS

AISI	-	American Iron and Steel Institute
ANOVA	-	Analysis of Variance
CNC	-	Computer Numeric Control
GPa	-	Giga pascal
HSS	-	High Speed Steel
mm	-	Millimeter
LST	-	Laser Surface Technology
kg	-	Kilogram
NC	-	Numerical Control
Mn	-	Manganese
MPa	-	Mega pascal
PA	-	Parallel to cutting edge
PE	-	Perpendicular to cutting edge
$\mu\text{in}$	-	Micro inches
$\mu\text{m}$	-	Micro meter

# CHAPTER 1

## INTRODUCTION

### 1.0 Introduction

The chapter one will be explain about the introduction of this project. It consists of the project background, problem statement, objective, and work scope.

### 1.1 Project Background

In this modern age, there are many challenges in the manufacturing industry. The quality of the machined parts and increase the productivity are the examples of the main challenges in this industry. The lot of researches have been conduct, in order to identify the difference method for optimise the machining parameter which significant with the machining process optimization during the turning machining operation. (Bharilya, Malgaya, Patidar, Gurjar, & Jha, 2015).

Metal cutting is one of the most important manufacturing processes, That is because parts manufactured by casting, forming and various other shaping processes often require a further metal cutting operation before the product is ready for use. In metal cutting, a cutting tool is used to remove excess material from a work piece in order to convert the remaining material into the desired part shape .Proper selection of tool materials, cutting parameters, tool geometry and machine tools is essential to produce high-quality products at low cost. Therefore, many attempts have been made to reduce cost and improve quality through the understanding of the cutting process.

The Taguchi experimental design method is a well-known, unique and powerful technique for product/process quality improvement. It is widely used for analysis of experiment and product or process optimization. (Madhavi, Sreeramulu, & Venkatesh, 2017). This project will come out with the optimization of the parameter of the tool wear based on the surface texture consider with the parameter of CNC turning machine.

## **1.2 Problem Statement**

In recent decades, efforts to increase productivity and minimise costs in machining processes have been important aspects. Higher material removal rates and better product qualities have been obtained by using new cutting tools. New cutting tools have greatly been improved machining of several engineering materials, even in some case of difficult-to-cut metals. There are still some problems in machining processes; one of them is the occurrence of high temperature in cutting zone. The rising of temperature during cutting processes negatively affects tool life. It also adversely changes machine parts quality, such as dimensional accuracy and surface quality.

During machining, the chip flows over the rake face of the tool with high velocity leading to intimate contact between the chip and tool which results in high normal pressure and temperature at the contact region. As a result, severe friction occurs and the tool wear mechanisms such as abrasive, adhesion and chemical dissolution are triggered. The tool wear affects the surface integrity of the work piece and the cutting performance of the tool. Therefore, it is essential to improve the tribology at the tool-chip interface. (Vasumathy & Meena, 2017).

### 1.3 Objective

The objectives of this project are:

- To determine the significant factor of parameter that influence the boron tool flank wear based on the surface texture design.
- To identify the optimum parameter of boron tool flank wear with surface texture in wet turning machining process on AISI 1018 Low Carbon Steel.

### 1.4 Work Scope

- i. Three types of surface texture on the boron cutting tool insert that used in this project are perpendicular, wavy and eclipse.
- ii. Machining process will be conduct by using Computer Numerical Control (CNC) turning machine.
- iii. The machining run in wet condition. So, the cutting fluid will be used during turning machining operation.
- iv. Material that be used is AISI 1018 low carbon steel rod.
- v. Layout Design using  $L_9$  Orthogonal Array and ANOVA (Analysis of Variance).
- vi. The engraving surface texture design will be engraving by CNC laser machine.
- vii. The Flank wear will be analysis by using the optical microscope.

## CHAPTER 2

### LITERATURE REVIEW

#### 2.0 Introduction

The chapter two will be some discussion about the research background related to the project. This chapter also discuss about the journals were make as references and good example from other sources that related with project.

#### 2.1 Turning

The turning process is the process that reducing the external diameter of cylindrical part and it the process of machining to manufacture the cylindrical work piece. The decreasing of the diameter work piece by using turning commonly into specified size and in order to produce a good surface finish product. Turning process regularly the work piece should be rotate in order to close segment have dissimilar diameter. Fundamentally, it can describe as the machining process of the outer surface part and the motion rotating involve in this process by using the cutting tool feeding into the work piece at the specific feeding distance. Figure 2.1 shows the fundamental of turning process to produce the cylindrical part. (Butola, Jitendrakumar, Vaibhavkhanna, Ali, & Khanna, 2017).

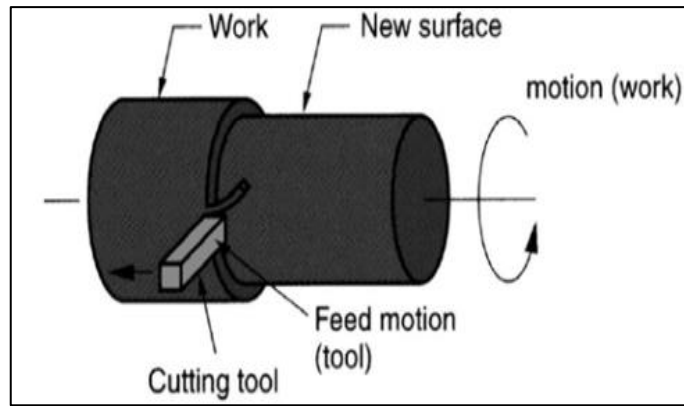


Figure 2. 1: Fundamental of Turning Process to Produce the Cylindrical Part

Turning is a shaping process of material by remove the outer surface and it is a form of machining. Turning process need a turning machine, work piece, fixture, and cutting tool to shape the material by reducing the outer diameter. To allow the work piece rotate at high speed the work piece is connected to the rotating fixture or device of the turning machine. In order to create the desired shape the cutting tool feed toward to the rotating work piece with parallel motion and remove the outer diameter of material in the form of chip. The improvement of the tribology properties and fatigue strength of the material need increase in order to get the good surface finish. The value of surface roughness is bigger influence by feed rate of parameter turning machining. The spindle speed parameter is the moderate factor that influence surface roughness. While, the depth of cut not affect the surface roughness. (Madhavi et al., 2017).

### 2.1.1 Turning Machine

The turning machines are almost same with lathes. In term of manufacturing, the lathes can be categorized by engine, turret, automatics, and numerical control. The machine is capability to handle the tool movement and heavy duty machine tools. The common of the range size of this machine are 24 to 48 inches from the centre distance and 12 to 24 inches

from the side. Mostly the turning machine or lathes machine are provided with coolant circulating system and chip pans. (Butola et al., 2017).

### 2.1.2 CNC Turning Machine

The machining process is machine control by using Computer Numerical Control (CNC) technology. Through CNC machine, it can produce the high quality machining components part and the superior material removal rates can be obtained. Generally, CNC turning machine is operating by certain parameter such as spindle speed, feed rate and depth of cut. (Gowd, Goud, Theja, & Reddy, 2014).

The CNC turning machine is completely automated and intelligent machining process. The machine is automatic determine the cutting state based on the parameter machining require and an estimate it by neglect any cutting condition. With this situation it complimentary to study the methodology in order to identify state of machining cutting. (Tangjitsitcharoen & Moriwaki, 2008).

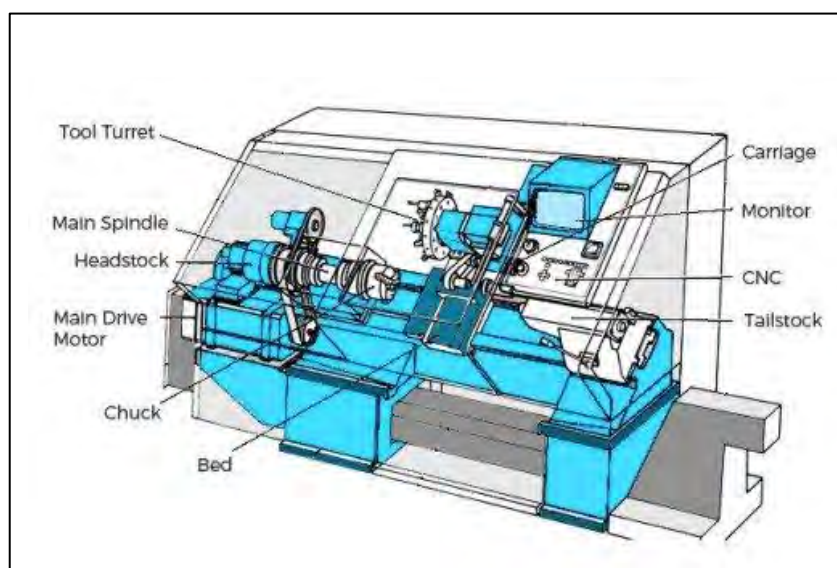


Figure 2. 2: Main Part of CNC Turning Machine